Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant

Appendix WRAC

United States Department of Energy
Waste Isolation Pilot Plant

Carlsbad Area Office
Carlsbad, New Mexico

Waste Removal After Closure

CONTENTS

CONTENTS (Continued)

FIGURES

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ACRONYMS

CAG	Compliance Application Guidance
CFR	Code of Federal Regulations
CH	contact-handled
DOE	Department of Energy
DRZ	disturbed rock zone
EPA	U.S. Environmental Protection Agency
GSSI	Geophysical Survey Systems, Inc.
HEPA	high efficiency particulate air
HSLA	high-strength low alloy
LWA	Land Withdrawal Act
MB	marker bed
MgO	magnesium oxide
RH	remote-handled
SWB	standard waste box
TRU	transuranic
WHS	waste handling shaft
WIPP	Waste Isolation Pilot Plant

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APPENDIX WRAC

This analysis discusses the techniques that could be applied in removing transuranic (TRU) waste from the Waste Isolation Pilot Plant (WIPP) repository after disposal. Title 40 Code of Federal Regulations (CFR) § 191.02(l) defines disposal of waste in a mined geologic repository as occurring "...when all of the shafts to the repository are backfilled and sealed." This report will serve to document compliance with the requirement in 40 CFR § 191.14(f) that the disposal system not preclude "...removal of most of the waste ...for a reasonable period of time after disposal." The removal discussion is based on currently available technologies. The reasoning for waste removal is not considered relevant except that it is assumed the destination and transportation mechanism for the removed waste will be known. Transportation methods, end use, and destinations of the removed waste are not considered in this analysis.

WRAC.1 WIPP Mission Description

The WIPP is a research and development facility of the U.S. Department of Energy (DOE) designed to demonstrate the safe transportation, handling, and disposal of defense-generated TRU radioactive waste. The facility is located 26 miles (42 kilometers) east of Carlsbad, New Mexico. The repository is located in a salt deposit, 2,150 feet (655 meters) below ground. The waste will be shipped to the facility from numerous generator sites around the United States and placed in the underground repository for disposal. Figure WRAC-1 details the WIPP location and Figure WRAC-2 contains a diagram of the WIPP surface and underground facilities. The facility is scheduled to begin disposal operations in 1998. A comprehensive description of the WIPP disposal system is presented in Chapter 2.0. A description of the planned operation and closure of the facility is in Chapter 3.0. The waste is described in Chapter 4.0.

WRAC.2 Analytical Scope

This analysis examines the feasibility of removing emplaced waste from the WIPP repository after closure. The regulatory and technical bases for removal are discussed. The emplacement and closure scenarios are defined to describe the condition of the repository and waste after closure. The sequence of steps for removal are described including a detailed discussion of their implementation. Since today's equipment is used to mine materials deposited millions or billions of years ago, it is technically feasible to remove the waste anytime during the regulatory time frame. The feasibility of waste removal is demonstrated by describing a method for waste removal.

For the purposes of this feasibility analysis, it is important to distinguish the difference between waste removal and waste retrieval. Waste removal differs from waste retrieval in that removal refers to actions taken after the repository is closed and sealed. Retrieval, which is essentially the reverse of emplacement, refers to recovering the waste prior to waste panel closure. This analysis specifically deals with waste removal.

WRAC.3 Regulations Applicable to This Feasibility Analysis

As an assurance requirement in 40 CFR Part 191, waste removal is one of several cautious steps that are to be taken to reduce the problems caused by the uncertainties inherent in the long-term predictions of disposal system performance. The EPA believes that recovery of the waste, though not necessarily easy or inexpensive, would be prudent in the event some future discovery or insight made it clear that the wastes needed to be relocated. The EPA provides specific insights regarding the implementation of this requirement as well as criteria in 40 CFR Part 194 for judging the adequacy of the DOE's demonstration of compliance to this requirement. Each is discussed below.

WRAC.3.1 40 CFR Part 191 Requirements

40 CFR § 191.14(f) states, "Disposal systems shall be selected so that removal of most of the waste is not precluded for a reasonable period of time after disposal". With respect to the recovery of waste after disposal, the preamble to 40 CFR Part 191 (50 *Federal Register* (FR) 38082) states that

> ...any current concept for mined geologic repository meets this requirement without any additional procedures or design features. For example, there is no intent to require that the repository shafts be kept open to allow future recovery. To meet this assurance requirement, it only need be technically feasible (assuming current technology levels) to be able to mine the sealed repository and recover the waste - albeit at substantial cost and occupational risk" (EPA 1985).

WRAC.3.2 40 CFR Part 194 Certification Criteria

40 CFR § 194.36 states that

> Any compliance application shall include documentation which demonstrates that removal of waste is feasible for a reasonable period of time after disposal. Such documentation shall include an analysis of the technological feasibility of mining the sealed disposal system, given technology levels at the time a compliance application is prepared.

By way of guidance for the requisite analysis referenced in the criterion, the EPA has provided a specific list of expectations in its Compliance Application Guidance (CAG) (EPA 1996). In the CAG, the EPA states:

> EPA expects the required analysis to include:
>
> - a sequence of procedures or steps which would need to be accomplished in order for waste to be removed from the disposal system after closure;
>
> - a discussion of how the sequence described above could be implemented, including descriptions of how currently available equipment and technologies could be utilized; and

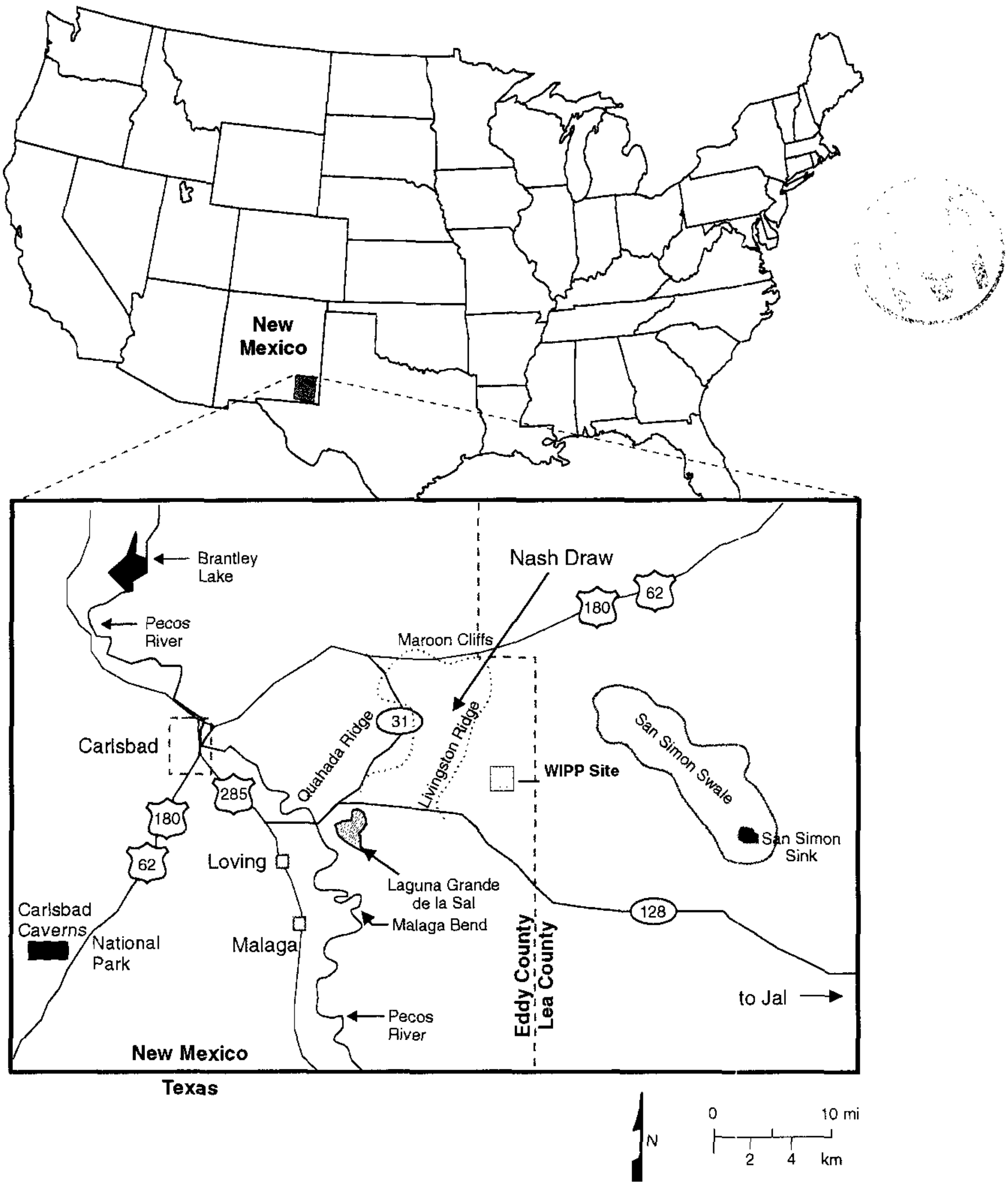

Figure WRAC-1. General Location of the WIPP Facility

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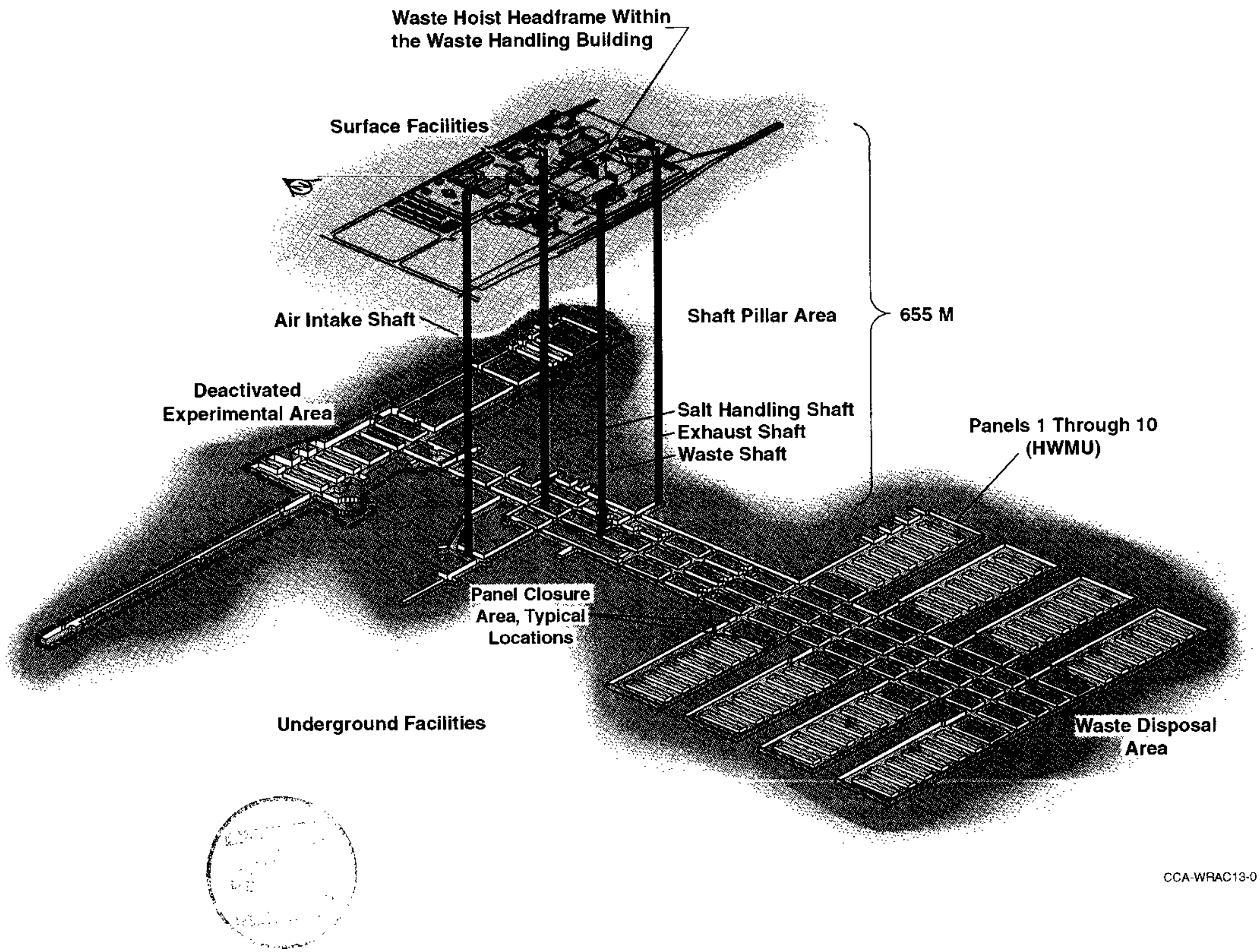

Figure WRAC-2. WIPP Surface and Underground Facilities

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- an estimate of how long after disposal it would be technologically feasible to remove the waste, based on the disposal system design and closure, and using the system and equipment described in the application. (EPA 1996, 66)

The following feasibility analysis examines and addresses this criterion and the implementation guidance. Background information is provided as part of the feasibility analysis. This background information includes a description of the disposal system and the waste at the time of disposal and the assumed condition at the time of removal (to the practicable extent to which this condition can be anticipated).

WRAC.4 WIPP Repository Description

The WIPP will dispose of TRU waste in rooms 2,150 feet (655 meters) below the surface. These rooms are mined in a bedded halite (salt) layer known as the Salado Formation (hereafter referred to as the Salado). The Salado is approximately 2,000 feet (610 meters) thick at the repository location. Figure WRAC-3 shows the general geologic cross section of the WIPP site. The underground repository is mined on one contiguous working level. With the exception of the shafts and sumps, no excavations are located above or below this level. The waste will be emplaced in eight panels, each panel composed of seven rooms, and the inter-connecting access entries (drifts) identified as Panels 9 and 10. The rooms are mined to the initial dimensions of 300 feet long by 33 feet wide by 13 feet high (91 meters by 10 meters by 4 meters). The repository layout is shown in Figure WRAC-4. The waste will be emplaced in the shaded areas of Figure WRAC-4.

The waste will be composed of radioactive and hazardous waste materials generated by the DOE's nuclear weapons programs. The materials are primarily laboratory and production equipment such as glassware, solidified spent solvents, cleaning rags, laboratory clothing, solidified sludges, metal tools, pipes, plastics, and paper. TRU waste is defined as waste contaminated with alpha emitting radionuclides having atomic numbers greater than 92, half-lives greater than 20 years, and a specific activity greater than 100 nanocuries per gram. Some of the waste to be disposed of at WIPP will contain hazardous constituents as defined by the Resource Conservation and Recovery Act (RCRA). This waste is referred to as TRU mixed waste. The waste is currently generated or stored at numerous sites in the United States.

There are two classifications for the TRU waste, contact-handled (CH) TRU and remote-handled (RH) TRU. The CH-TRU waste is defined as TRU waste packaged in containers whose maximum surface dose rate does not exceed 200 millirem per hour. Surface dose rates greater than 200 millirem per hour are classified as RH-TRU waste. For emplacement into the WIPP the RH-TRU surface dose rates cannot exceed 1,000 rems per hour with a maximum total of five percent of the canisters exceeding 100 rems per hour. The total maximum activity for RH-TRU waste at WIPP cannot exceed 5.1 million curies. These limits including a maximum TRU waste volume of 6,200,000 cubic feet (175,588 cubic meters) are established by the Land Withdrawal Act (LWA).

The high radiation associated with RH-TRU waste is due to the presence of isotopes of cesium, strontium, barium, plutonium, and yttrium. The longest half-life among these isotopes is 30.0 years. Therefore, after about 300 years, the isotopes will have gone through a minimum of 10 half-lives and their radioactivity, relative to the longer lived isotopes associated with the CH-TRU waste, will be significantly diminished. For this reason, in discussion of the removal of waste after 300 years, the DOE does not distinguish between the RH-TRU and CH-TRU types.

It is anticipated that a majority of CH-TRU waste will be shipped to the WIPP in either 55-gallon (208 liter) drums or standard waste boxes (SWBs). The 55-gallon drums will be strapped together in an arrangement of seven drums called seven-packs. A seven-pack and an SWB are shown in Figure WRAC-5. Rows of containers will be placed in the rooms three high. The waste will also be emplaced in the panel access entries. After a panel is filled, a closure system will be constructed to isolate the waste from further operations. The closure system conceptual design uses concrete.

A backfill consisting of magnesium oxide (MgO) will be placed over, within, and around the containers of CH-TRU waste. Backfill will be emplaced in super sacks over the top of the waste stack and mini sacks within and around the waste. Backfill sacks are intended to burst as the room creeps closed, allowing the granular materials to be exposed to the room environment. Alkaline earth oxides (such as MgO) are known to readily react with water to form hydroxides. These hydroxides are free to react with carbonic acid that may form in the disposal room. The reaction buffers the brine to a pH which serves to reduce the amount of actinides in solution.

The RH-TRU waste canisters are constructed of painted carbon steel, 26 inches (66 centimeters) in diameter with a maximum length of 121 inches (307.3 centimeters). The maximum weight of a filled canister is 8,000 pounds (3628.7 kilograms) (DOE 1991). In order for personnel to handle the RH-TRU waste, the RH waste canisters must be shielded to reduce radiation levels to allowable limits. The shielded facility cask is used to transport RH-TRU waste to the underground. The RH-TRU waste canister will be emplaced in a disposal room wall prior to CH-TRU waste emplacement in that room. The waste canister is pushed out of the facility cask and into a horizontal borehole in a disposal room wall. The borehole is then closed with a shield plug. The shield plug is a cylinder 29 inches (73.7 centimeters) in diameter and 70 inches (177.8 centimeters) long with a wall thickness of 1.5 inches (3.8 centimeters). The bottom of the plug is constructed from a 5-inch (12.7-centimeter) thick plate. The 3-inch (7.6-centimeter) thick top plate also has a standard waste handling pintle. The total weight of the plug is approximately 4,200 pounds (1,905 kilograms). All emplaced RH-TRU waste locations will be recorded.

WRAC.4.1 Repository Configuration at the Time of Closure

The anticipated final configuration of the repository at the time of closure is shown in Figure WRAC-6. This is the configuration that is used as input to the conceptual model developed to

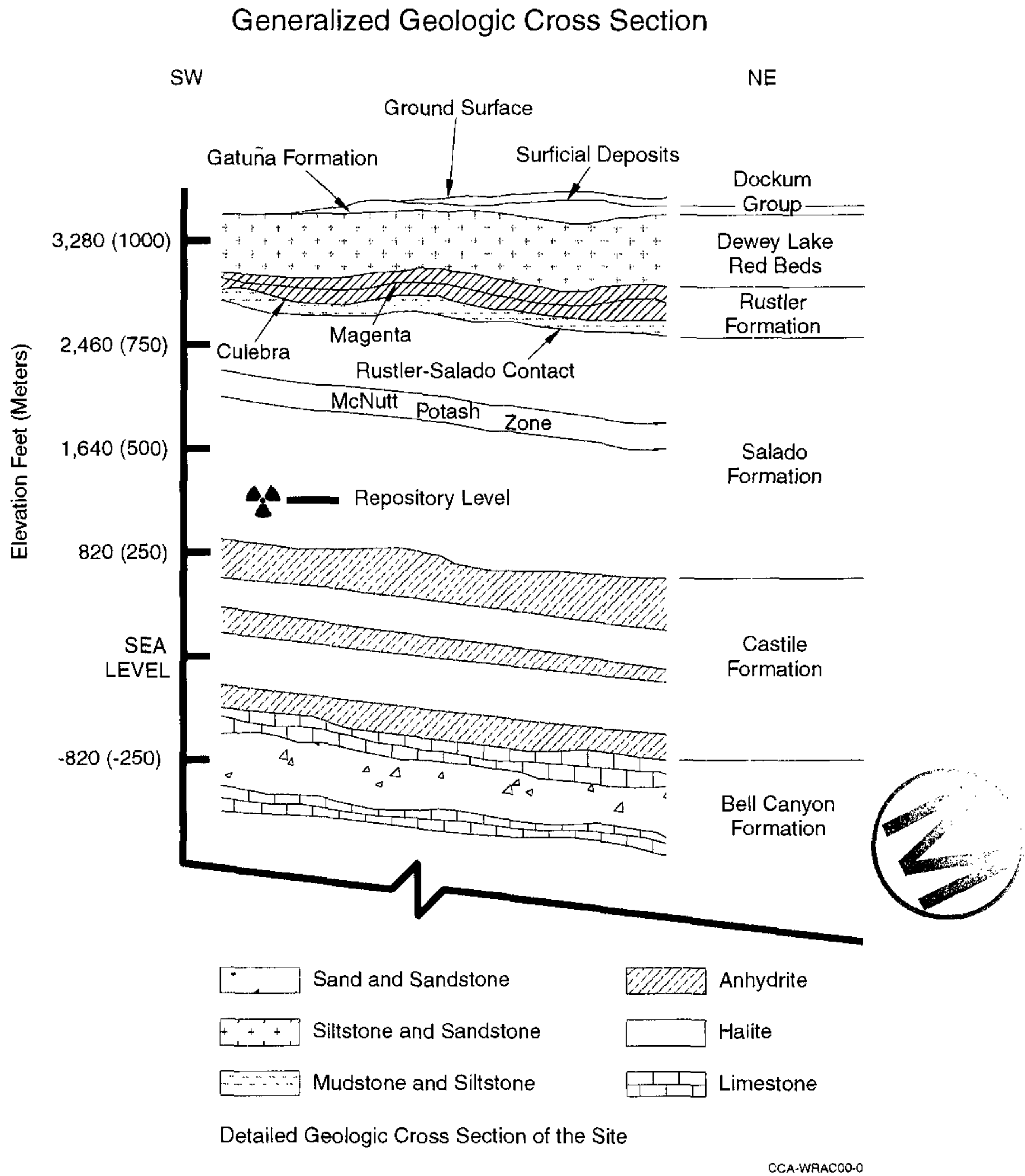

Figure WRAC-3. Generalized Geologic Cross Section

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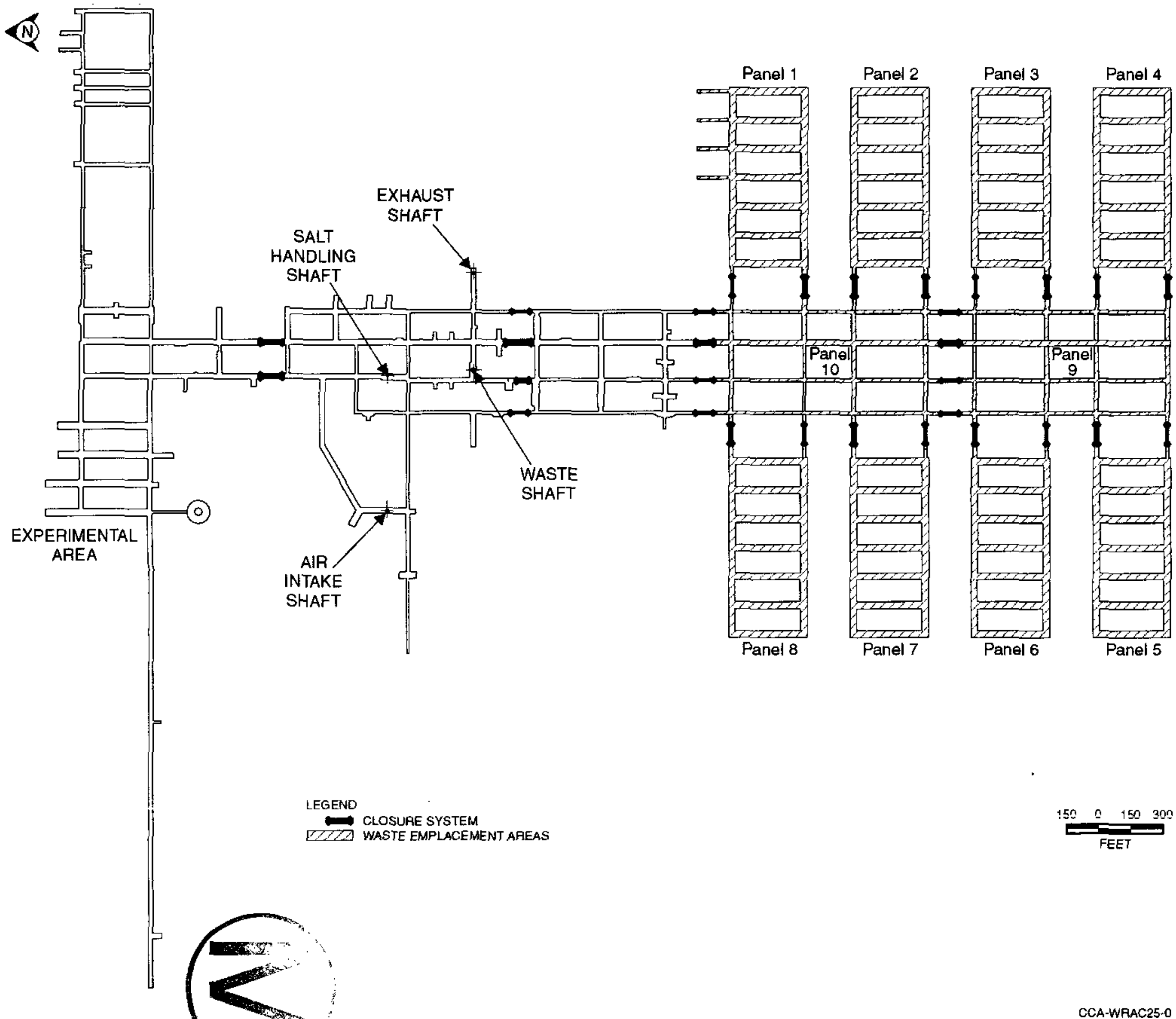

Figure WRAC-4. Repository Layout

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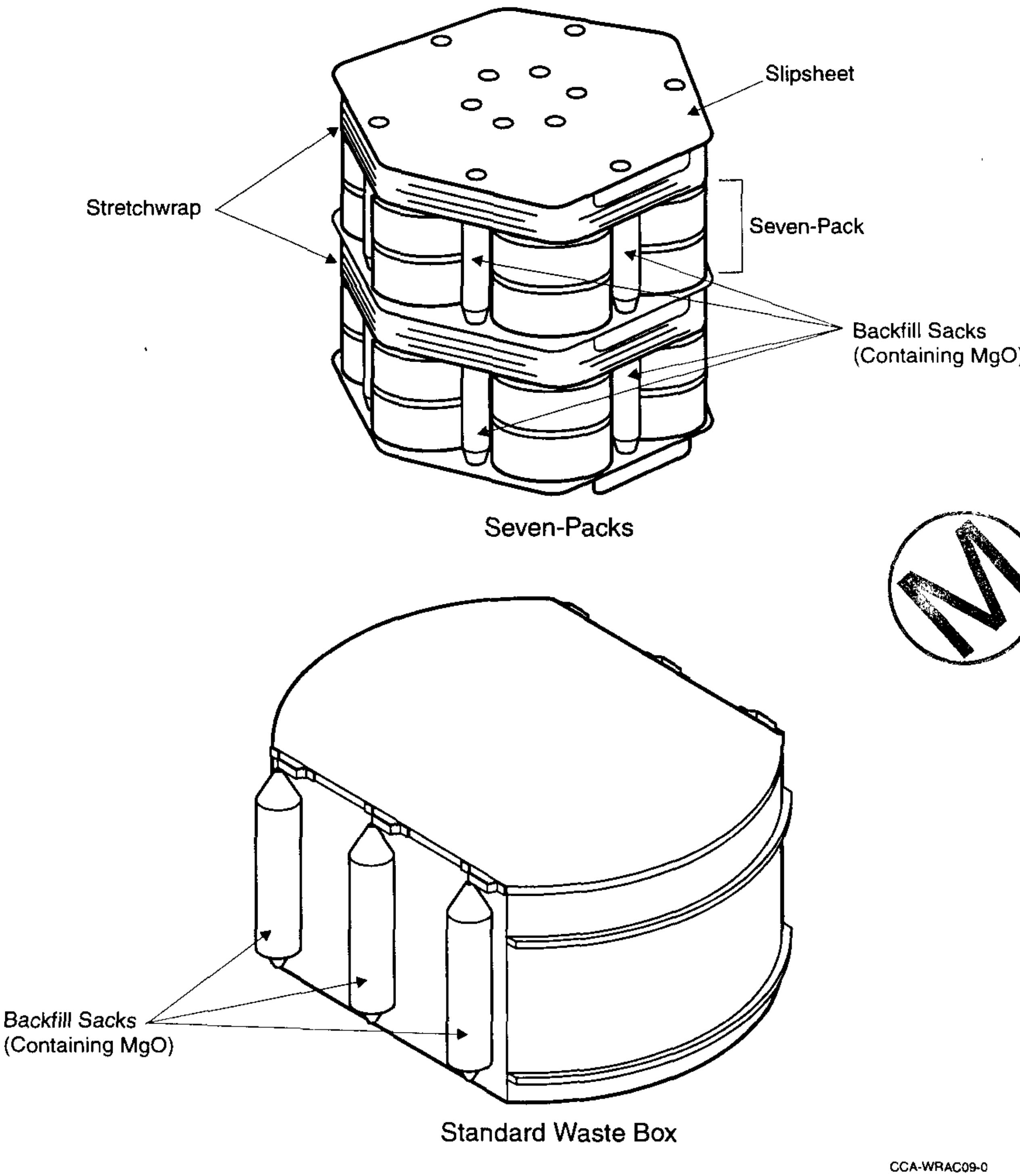

Figure WRAC-5. SWB and Seven-Pack Configuration

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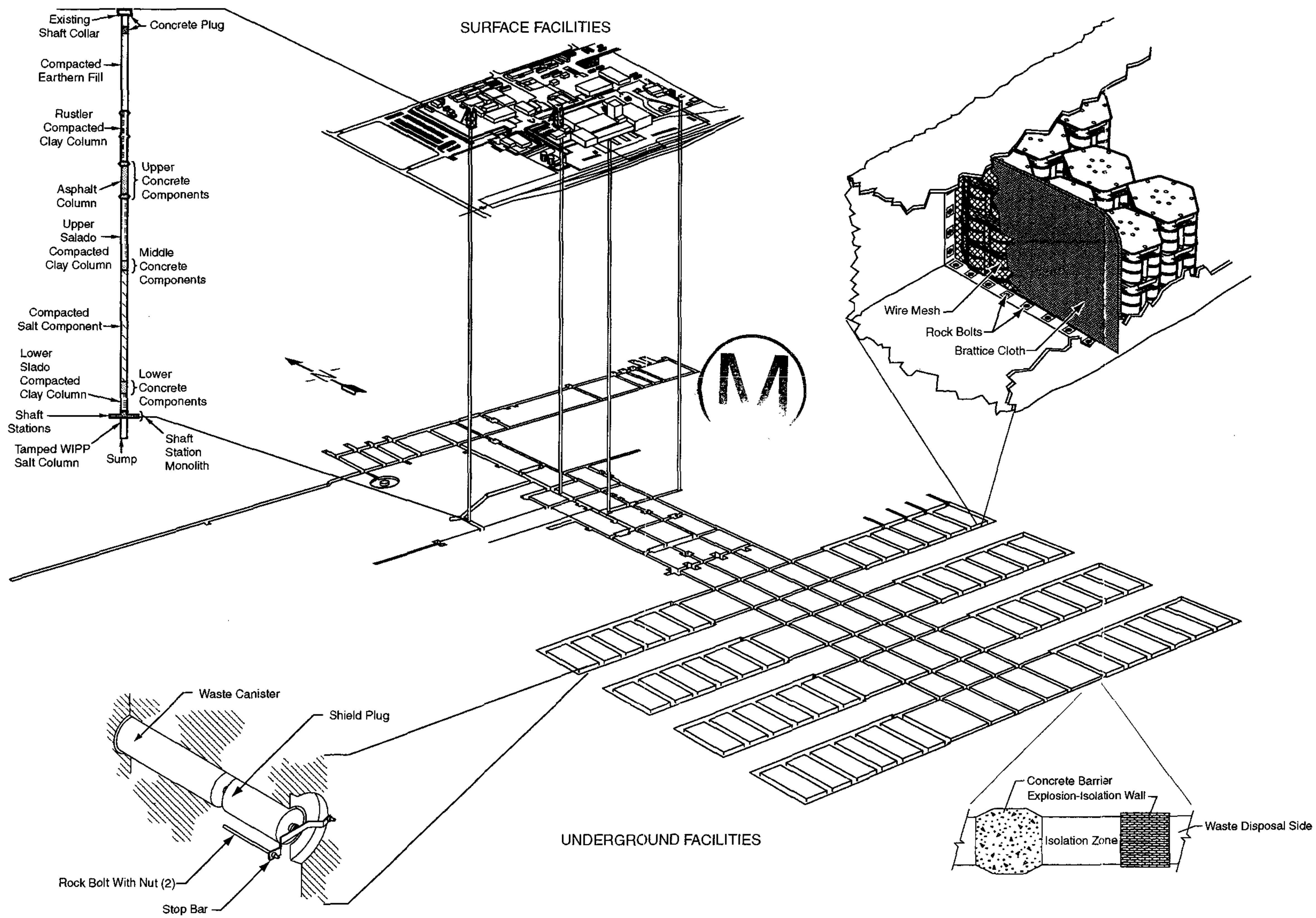

Figure WRAC-6. WIPP Repository at Time of Closure

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predict repository performance. The model geometry is discussed in Chapter 6.0, Section 6.4.2.1 and includes 30 separate elements. Those of interest to this analysis are Regions 23 to 27 in Figures 6-13 and 6-14 in Chapter 6.0. These regions include the waste disposal panel (Region 23), panel closures (Region 25), the panels and access drifts in the rest of the waste disposal area (Region 24), the operations region (Region 26), and the experimental region at the north end of the excavation (Region 27). In addition, the conceptual model described in Section 6.4 of Chapter 6.0 incorporates the stratigraphic units surrounding the repository into the model as discrete regions. These include the Salado Formation outside the disposal region (Region 19), MB138 (Region 20), Anhydrite Layers A and B (Region 21), the disturbed rock zone (Region 22) and MB139 (Region 28) (as shown in Figure 6-13 in Chapter 6.0). Parameter values have been assigned to important properties (such as porosity and permeability) of these various regions. Initial values and value ranges are summarized in Table 6-8 in Chapter 6.0 and are detailed in Appendix PAR.

The LWA limits the total disposed TRU waste to 6,200,000 cubic feet (175,600 cubic meters). After waste emplacement is complete, the surface structures will be decontaminated and decommissioned. This will include decontaminating the surface facilities and dismantling the aboveground structures. TRU waste generated by these activities will be emplaced in the repository, the last waste panel will be closed, and the remaining access entries will be backfilled. The four shafts will be sealed using crushed Salado salt in combination with other materials such as concrete, cementitious grout, clay, and asphalt. Appendix SEAL details the shaft seal design.

WRAC.4.2 Repository Condition at Time of Removal

The requirement to remove the waste does not specify when or if removal would occur, only that removal not be precluded. The condition of the repository is time dependent with respect to salt reconsolidation and waste compaction. For the purposes of this analysis, the DOE assumes that the reason for removal is the result of a discovery or insight gained by a future generation and not the result of an event that necessitates removal. This is reasonable because any such event that would make it necessary to remove waste would have to be cataclysmic in nature (such as meteor strike or volcanic activity). Such events, if they were sufficiently likely to be of concern, would be included in the assessment of the disposal system performance. All such events have been screened out as unlikely as discussed in Section SCR.1 of Appendix SCR. As the result of this assumption, there are no time or cost limits imposed on the removal process in this analysis. Radioactive contamination within the disposal region can be removed at whatever rate is necessary to safely manage occupational and public exposure.

Additional assumptions include the following.

- The reason for waste removal is known and what will be done with the waste is unimportant. This analysis need only demonstrate removal feasibility.

- The length of time the repository has been closed at the time of removal is known to those planning the removal and the anticipated conditions of the waste panels and panel closure can be determined for use in designing removal systems (see Chapter 6.0 and Appendix SCR for a discussion of rock creep and porosity and permeability values assumed for performance assessment).

- The CH-TRU containers have been breached.

- Removal of most of the waste means that all waste within the disposal region will be removed, however contamination that has migrated into marker beds and moved out of the disposal region will not be removed.

Numerical calculations have been performed for the repository which are focused on predictions of performance over 10,000 years. In the shorter term, the configuration of the excavation and waste within the repository is changing as it reaches a steady state configuration. As steady state is reached, the brine inflow rate is affected by the increasing pressure in the repository caused by gas generation and creep closure. These three phenomena are related in the numerical modeling that is detailed in Chapter 6.0. All of these phenomena and the various associated states of the excavation need to be considered in evaluating the feasibility of removal. In no case, however, are conditions expected to render removal impossible.

Gas generation affects pressure within the excavation, which in turn is an important parameter in creep closure. The computer simulation of this process uses an average-stoichiometry model to estimate the potential for gas generation in the waste disposal region. Parameter values for the average-stoichiometry gas generation model are in Section 6.4.3.3 of Chapter 6.0. Modeling shows that gas pressure in the disposal room can range from slightly above atmospheric to near lithostatic. The model assumes that interbed fracturing occurs at high pressures thereby limiting pressure buildup. If the agency removing the waste in the future anticipates that high pressures are present, techniques are available to detect and safely relieve such pressures. Such techniques are currently in use in the WIPP to prevent dangerous pressure blowouts from localized pressurized zones ahead of mining. The technique involves drilling small diameter probe holes into the rock ahead of the mining machine.

For the computer simulation used in this analysis, the DOE conceptualized the Salado as a porous medium composed of several rock types arranged in layers, through which fluid flow occurs according to Darcy's Law. This model was chosen because it can be simulated using standard numerical techniques and because it is the most conservative of the three mechanisms in that it predicts the maximum rate and cumulative volume of brine inflow. Two rock types, impure halite and anhydrite, are used to represent the intact Salado. Near the repository, the disturbed rock zone (DRZ) has increased permeability compared to intact rock and offers little resistance to flow between anhydrite interbeds and the repository. Except for the DRZ and anhydrite interbeds, under certain circumstances, this simulation assumes spatially constant properties for Salado rock repository. The inference is that there is little variation in large-scale averages of rock or flow properties across the disposal system. Assumptions about Salado flow in general are presented in Section 6.4.3.2 of Chapter 6.0. This model serves to maximize the potential brine inflow to the repository.

In the computer simulation, brine flows from the Salado and into the repository in response to fluid potential gradients that form over time. Because of the low permeability of the impure halite and relatively small surface area of the excavation, direct brine flow between the impure halite and the repository is limited. The interbeds, however, can serve as conduits for brine flow between the impure halite and the repository. Conceptually, brine flows laterally along higher-permeability interbeds towards or away from the repository and vertically between the interbeds and the lower-permeability halite. Because the interbeds have a very large contact area with adjacent halite-rich rock, even very small flux from the halite into the interbeds (for brine inflow) or to the halite from the interbeds (for brine outflow) can accumulate into a significant quantity of brine.

Alternatively, in the modeling for the disturbed case, brine could flow into the repository as the result of a drill hole that connects a disposal panel with the Castile Formation. In such a case, a portion or all of the excavation could be saturated with brine. Removal feasibility must consider a range of brine saturation ranging from dry to saturated.

Creep closure of the excavation is the focus of a computer model that implements the repository processes associated with rock properties in the repository rooms and the shafts. The amount of waste consolidation resulting from creep closure, and the time it takes to consolidate the waste, are governed by properties of the waste (waste strength), properties of the surrounding rock, the dimensions and location of the room, and the quantities and pressure of fluids present in the room. Creep closure of waste disposal areas will cause their volume to decrease as the Salado deforms to consolidate and encapsulate the waste, changing waste porosity and permeability. Waste strength and fluid pressure may act to resist creep closure. The conceptual model implementing creep closure is discussed in Section 6.4.3.1 of Chapter 6.0.

Fluids that could affect closure are (1) brine that may enter the repository from the Salado and is present in the repository when it is sealed, and (2) gas produced by reactions occurring during waste degradation. Closure and consolidation slowed by fluid pressure in the repository can be quantified according to the principle of effective stress:

$$\sigma_T=\sigma_e+p \qquad (1)$$

where σ_T is the stress caused by the weight of the overlying rock and brine (an essentially constant value), p is the pressure of the repository pore fluid, and σ_e is the stress that is applied to the waste skeleton or matrix. In this formulation, the waste is considered a skeleton structure immersed in pore fluids. As the pore pressure increases, an increasing amount of overburden stress is supported by pore fluid pressure, and less overburden stress is supported by the strength of the waste matrix. Because of the strength, waste consolidation can cease even if pore fluid pressures do not reach lithostatic. If gas and brine quantities in the repository stabilize, creep closure will act to establish a constant pressure and void volume.

Creep closure becomes an important consideration for the removal process since it determines, to a major extent, the dimensions of the excavation that is needed to remove the waste and the condition of the rock that must be mined. Conditions where the creep has been minimal also indicate the situations where brine content or gas pressure are highest and represent the most hazardous conditions.

WRAC.4.3 Summary of Conditions to Be Anticipated for Removal Feasibility

Based on the descriptions in the preceding sections, there are five potentially hazardous conditions that must be anticipated in preparing for the removal of disposed waste. These are radioactivity, hazardous constituents, gas, brine, and rock integrity.

The amount of radioactivity depends on the time at which removal is initiated. Within the first 300 years of disposal, it may be necessary to consider treating (removing) RH-TRU and CH-TRU waste differently, because of higher radioactivity. Beyond 300 years, all the waste can be managed as CH-TRU waste. Regardless of when removal is initiated, the inventory of the waste documentation that will be accumulated by the DOE during operations and archived after closure will contain sufficient information to determine rather precisely the radioactivity levels to be anticipated and the locations of any containers of waste that may pose higher radioactivity hazards.

With regards to the hazardous constituents in the waste, the volatile organics do not occur in sufficient quantities to pose a hazard as long as adequate ventilation is provided. Non-volatile hazardous constituents only pose threats if they are released during the removal process. Here, as with both the volatile components and the radioactive contaminants, proper ventilation will be needed to provide adequate protection to workers, the public, and the environment. If environmental protection laws are the same at the time of removal as they are today, the planning for removal will require that the agency implementing removal provide detailed plans for controlling hazardous constituent contamination.

Gas pressures can range from one atmosphere (14.7 pounds per square inch or 0.101 megapascals) to pressures near 2,000 pounds per square inch (13 megapascals). Experience with mining in halite indicates that in virgin rock, high pressure zones are maintained because of the low permeability of the rock. Therefore, mining activities are conducted in anticipation of pressure in areas where such pressures are known to exist. Due to the nature of the disposal operations and the panel closure practices, pressures could vary from panel to panel.

Brine quantities can vary from little to no brine, caused by brine consuming processes such as corrosion and microbial degradation, to panels full of brine as the result of a borehole that connects the repository with a brine pocket in the Castile Formation. As with gas, the quantity of brine can be different from one panel to the next because of the anticipated efficiency of the panel closures.

The amount of pore space in a disposal panel can be used to represent the degree of consolidation that has occurred due to creep closure. While brine and gas can act to maintain rather large pore volumes in a sealed panel, this condition is considered unlikely since creep closure acts fairly rapidly and it is unlikely that sufficient brine and subsequent gas will be available to support large pore volumes without an external source such as a Castile brine pocket. Because active and passive controls are expected to deter human intrusion for up to 700 years after closure, an encounter with such a brine source is not expected during this time period. Consequently, the repository is expected to reach its maximum closure before large quantities of brine are available. In this case, the resulting pore volume is likely to be about 30 percent and the excavation will have closed to less than half of its original height.

Each of the factors above represent variable conditions that the removal planning activity must evaluate prior to actually removing the waste from the repository. None of these are expected to create conditions that will render the waste impossible to remove. However, the safety hazards imposed by the ranges of possible conditions dictate careful evaluation and appropriate planning prior to removal.

WRAC.5 Sequence of Steps to Remove Waste

The DOE has identified a sequence of five phases for implementing removal:

Phase 1 — planning and permitting.

Phase 2 — initial aboveground setup and shaft sinking.

Phase 3 — underground excavation and facility setup of underground ventilation, radiation control, packaging areas, decontamination areas, maintenance, remote control center, and personnel support rooms.

Phase 4 — waste location and removal operations, including mining waste removal, packaging, package surveying and decontamination, transportation to surface, staging for off-site transportation, and off-site transportation.

Phase 5 — closure and D&D of the facility.

Each of the five phases is summarized below and described in detail in Section WRAC.6.

WRAC.5.1 Planning and Permitting

A decision to remove waste will initiate the planning and permitting phase. Permitting requirements will be based on governing regulations at the time removal is authorized. The planning and permitting program will identify all permits and research the available technologies at that time to determine available removal techniques and the condition of the repository. After initial research is completed, a plan will be drafted to itemize and schedule all removal activities. It is at this stage that initial estimates of the condition of the waste will be made. These will be based on the performance assessment results, the record of reassessments that may have been done as the facility was filled, the records of the waste that was actually placed in the facility, and any other information that may be useful in determining the status with regard to pressure, water content, and disposal room configuration. Strategies for evaluating the conditions in the repository will be developed. These may include surface drilling or drilling from within an initial excavation adjacent to the waste areas. Appropriate geophysical techniques and other remote sensing measures will be identified for determining the condition of the waste areas in a manner that minimizes the chance for radiation exposure.

WRAC.5.2 Initial Aboveground Setup and Shaft Sinking

Aboveground support buildings will house the exhaust fans and any radiation control equipment such as HEPA filters, administration facilities, operations and maintenance facilities, control center, waste staging and decontamination areas, the warehouse (containers), laboratories, and others as deemed necessary. Initial estimates of the amount of mining necessary will be made based on the results of the planing phase. The amount of mining will dictate the size and capacity of the surface support facilities.

WRAC.5.3 Underground Excavation and Facility Setup

After the shafts are completed, drifts will be run and ventilation paths will be established using conventional mine ventilation techniques. During shaft sinking, provision will be made to test the muck prior to its release to the surface to detect radioactive or hazardous constituent contamination. If such contamination is found, shaft muck will be isolated for future disposition. If contamination is minor, this material will likely be isolated from the environment by placing it back into the facility at the time of closure. Underground support and service areas will be excavated. The location of the shafts and initial excavations will be determined based on the anticipated brine and gas conditions. These areas will have sufficient intact salt between them and the waste areas that seepage or blowout of contaminated brine or gas into the shafts and service areas will be precluded. There are not expected to be any limitations on the amount of distance that can be specified between the wastes and the service areas. Support rooms will be excavated for maintenance, control, and packaging. Air locks will be constructed to provide the necessary level of ventilation control and separation between contaminated and non-contaminated areas. All equipment required for removal, packaging, and related support equipment will be installed.

Excavation will be in two stages. Initial excavation will not contact waste and will provide for mine support rooms, haulage drifts, ventilation, and access to the waste. The second stage will remove the waste.

WRAC.5.4 Waste Location and Removal Operations

The waste removal will be performed in discrete operations depending on the anticipated level of radioactivity. The waste will be removed by mining the area where the waste was emplaced. The mined waste will be transported to the packaging areas. The waste can be removed many ways using standard equipment. Section WRAC.6.2 contains a brief description and describes the feasibility of using various mining techniques for waste removal. An appropriate level of radiological controls will be used depending upon the radioactivity of the mined waste.

WRAC.5.5 Closure and D&D of the Facility

After waste is removed from the repository, the facility will be decommissioned according to the current regulations at that time.

WRAC.6 Removal Implementation

To support the requirement that waste removal is not precluded, a system for waste removal is described using available mining technologies. This description includes standard shaft sinking practices and drift excavations. Standard mining techniques may be used until contamination or radiation exceeding personnel safety limits then in force are encountered. In these contaminated areas, currently available remote controlled mining equipment or equipment modified with off-the-shelf systems may be used. Where practical or necessary, removal operations will be performed remotely. All support, radiation and air quality monitoring, and geotechnical surveying will be performed remotely in the contaminated areas. The clean and contaminated areas will be segregated from each other and maintained using separate air intake paths and ventilation control structures.

The excavated waste and materials will be placed in appropriately designed waste containers. The container surfaces will be decontaminated if necessary prior to being transported aboveground. Aboveground facilities will include a control center where any necessary remote waste handling and packaging operations are coordinated, and a decontamination area where waste containers will undergo any necessary additional decontamination. The waste containers will be staged aboveground for transportation. A control center in the underground will provide the interface between the aboveground control center and the underground operational activities.

The mining and waste removal operations will be designed to reduce the amount of contamination and exposure to allow limited human access for assessments, equipment retrieval, and equipment repairs. Operations will be designed to reduce human involvement to the extent practicable. Radiological work will be performed using standard industry practices and approved procedures.

The mining operations will use standard equipment to sink the shafts and excavate the drifts and support rooms. After the underground support areas are completed, the waste will be removed. Smaller scale mining equipment will be used to perform the removal. Modifications to the equipment will enable the vehicles and support equipment to be remotely controlled and handle the waste materials. The length of time since disposal will determine whether or not the RH-TRU and CH-TRU wastes will be retrieved in separate operations. It is currently anticipated that the radioactivity level of RH will decay to CH levels within 300 years after disposal (DOE 1995). Thus if removal is conducted subsequent to 300 years after disposal, a single mining operation may remove CH and RH simultaneously. However, removal prior to that time may require separate operations. Because RH wastes may pose a greater radiation hazard, RH-TRU removal activities may be more rigorous in order to limit the exposure to personnel. RH-TRU waste should be removed as intact as possible.

The preamble to 40 CFR Part 191 states that waste removal must be feasible but would likely incur great cost and overall occupational hazard. No time limit is specified. The removal approach will include measures that reduce the overall hazards but will require a long time period to complete. No time limits or cost estimates are included in this study.

The removal requirement states that removal of most of the waste will not be precluded but does not quantify the term most. This study assumes that the quantity removed shall be the amount that can be removed practically. No quantitative figure is specified because removal is speculative. The amount that practically can be removed using the technologies available at the time of removal shall be achieved. Since today's equipment is very effectively used to mine materials deposited millions or billions of years ago, this same equipment technology would provide for the feasibility to remove the waste anytime during the regulatory time frame.

WRAC.6.1 Planning and Permitting (P&P)

The need to remove the waste would initiate the planning and permitting phase. By definition (40 CFR § 191.02[l]), waste removal does not occur until after disposal. The permitting requirements will be based on governing regulations at the time removal is authorized. The planning and permitting program will identify all required permits. This program will also research the available technologies to determine the appropriate removal techniques, the waste conditions, and the repository conditions (see Chapter 6.0 for performance assessment assumed conditions after repository closure). After the initial research is completed, a plan will be drafted to itemize and schedule all removal activities.

The following considerations would be included in the planning and permitting process for the WIPP. These are necessarily general since the actual activities are solely dependent on the conditions at the time removal is deemed necessary. It should be noted that technologically, removal could be accomplished without any of the steps in this section. Such brute force approaches would meet the requirement of describing feasible techniques for removal; they are not, however, considered to be prudent.

Availability of Records. Available records will be collected to determine the location of waste containers, the nature of the waste placed in the facility, the underground excavation conditions during operations and at the time of closure, the location of seals and panel closures, and the amount and nature of backfill materials. Since the DOE plans to place records in numerous locations, records should be readily available for needed evaluations. Additionally, WIPP will also have complete inventories of the contents of both the buried CH and RH containers.

Location of the Site. Records and markers will be used to identify site locations such as the previous shaft locations, the area of the disposal region footprint, previously drilled boreholes, location of monitoring activities, and other features that will aid in delineating the areas for new excavation and new surface structures.

Background Environmental Conditions. A baseline of environmental conditions will be established prior to any surface disturbing activity in order to get an accurate assessment of pre-operational conditions. Background measurements will be compared with environmental data stored in the site archives to determine any changes in conditions since the closure of the facility.

Time Since Disposal. This will be used to determine the expected condition of the disposal rooms, the amount of radioactivity and hazardous constituents that need to be dealt with, the amount of migration outside the disposal zone that may have occurred, and the presence of potential hazardous conditions such as pressurized gas and brine.

Facility Design. Initial facility designs will be prepared so that appropriate technologies can be identified and so that environmental impacts can be assessed. Release and exposure pathways will be identified and risk analyses performed to ensure appropriate environmental protection measures are taken. Design will be in accordance with applicable commercial and regulatory standards in effect at the time. Regulations such as those promulgated by the Occupational Safety and Health Administration and the Mine Safety and Health Administration will be given due consideration in designing systems that are protective of human health and the environment. Final facility design will be appropriately reviewed and approved by the implementing agency and appropriate regulatory organizations.

Permitting. Environmental regulations governing releases to environmental media and protection of the public from exposure to noise, gases, dust, hazardous waste, radioactivity, and other potentially harmful substance will be identified and appropriate permits obtained in the time frames dictated by the regulations.

Radiological Controls. The removal process will require a comprehensive assessment of the facilities and the precautions necessary to ensure the safety of workers and the public during the entire removal operation from initial coring until final closure and decommissioning of the facility. The facilities will include appropriate areas for washing and decontamination of containers and equipment and separate areas for the decontamination of personnel should such requirements arise. Decontamination areas and washing areas will be designed and constructed both in the underground and on the surface. Special areas will also be constructed on the surface and in the underground for storage of material and/or containers having high radiation levels. Such areas will be shielded to permit operational activities nearby without undue risk to personnel. Rigorous radiation and hazardous material monitoring of all activities from initial borehole drilling and coring to actual removal will be required until such time as removal activity experience provides sufficient information to understand the actual conditions existing in the repository and permit formulation of appropriate monitoring policy.

WRAC.6.2 Aboveground Setup and Shaft Sinking

Existing geological characterization data will be supplemented with new borings at the site. During all boring, shaft sinking, and mining activities in the vicinity of the waste panels careful monitoring will be conducted to ensure early determination of the presence of any hazardous or radioactive material. An initial shaft location sufficiently distant from the waste will be identified and drilled. Coring in the vicinity of the repository horizon will be preformed in order to capture any horizons that contain radioactive contamination caused by brine migration through marker beds. The level of contamination will be assessed and appropriate precautions taken to protect personnel, the public, and the environment from contamination. Such precautions are used today in cleanup activities in which contamination is kept within well defined barriers and entrance and egress is carefully controlled and monitored. Emphasis will be placed on avoiding the areas that were originally mined for the repository. The DOE currently believes that for the WIPP, the best approach to the waste is from the south because this area avoids the existing shafts and mined areas.

Use of the intact portion of the formation instead of using previous shafts and tunnels minimizes the ground control problems. Additional geological studies would be conducted to determine the adequacy of the rock south of the repository.

Aboveground support buildings will be constructed to house the exhaust fans and ventilation (HEPA) filters, administration offices, engineering offices, training facilities, safety facilities, maintenance support facilities, control center, waste staging and decontamination areas, and warehouse. Portable and/or temporary structures such as trailers could be used for miscellaneous activities. Power and water distribution network shelters will be required.

Where practicable, aboveground support facilities should be designed for later disassembly and removal to facilitate decommissioning. Removal facilities would closely resemble those currently in use at the WIPP and described in Chapter 3.0 with some additional radiological control facilities and decontamination facilities.

A shielded area for the protection of personnel from higher levels of radiation, similar in construction to the shielded storage room currently located in the Waste Handling Building (see Appendix D&D), may be required to handle and store the RH-TRU canisters and their containers prior to off-site shipment. This area will contain all the equipment necessary to transfer the RH-TRU waste into suitable waste containers and load shielded shipping casks. If necessary, remote operations can be used for any removed waste that exceeds CH-TRU safe handling levels.

Security fencing will be required around the facilities. The extent of the security devices required will be governed by the regulatory requirements at that time.

A control center will be located aboveground that houses the personnel and equipment that controls the remote mining equipment and all other remote operations.

At least three shafts will be constructed. The number and size of the shafts will be based on removal throughput requirements, airflow requirements, and mining regulations at that time. The underground ventilation requirement should be lower than the original ventilation system assuming a reduction in both manpower and diesel equipment usage. To reduce the discharge of hazardous and radioactive particulate contamination, the removal working area and packaging areas will be provided with separate HEPA filtration systems. This precaution will reduce migration of particulate material from the mining areas.

The three shaft concept would include two intake shafts and an exhaust shaft. The current WIPP shaft designs would be adequate, although technology improvements may make operations more efficient and reliable.

Each shaft will include a hoisting system. The waste handling shaft (WHS) and hoist will be fully enclosed and will allow air intake without backflow. The WHS will be an air intake shaft that ventilates the maintenance, packaging, and contaminated work areas of the mine.

The ventilation exhaust system for the removal of the waste will be significantly more complex than the system supporting waste emplacement. Because of the likelihood of the production of hazardous and radioactive particulate material during the remote removal of waste material, the ventilation system will require local systems within the underground that include the appropriate exhaust fans, monitoring, and HEPA filtration systems used to filter the exhaust air during removal operations. The levels of dust in a potentially highly contaminated environment will present a significant maintenance challenge. Maintenance of these systems will require high degrees of redundancy of system components, system configurations, or flow paths. Flexibility of operation will be a major operational requirement of the ventilation system design in order to ensure that removal operations remain within the regulatory and safety limitations imposed for workers and the general public. The system design must permit remaining within the allowable limits at all times. Since the potential for hazardous or radioactive material contamination will exist, once waste removal begins, filtration of all exhaust air will be required. Self-cleaning or roughing pre-filters may be used to increase HEPA filter life and reduce down time for filter change-out.

After the first shaft (no particular order) is completed, the others may be excavated from the bottom up using a drill and ream system similar to the system used at WIPP to excavate the existing air intake shaft. This will require access entries (drifts) to be excavated to the base of each shaft and drilling to this area. An ore transfer station will also be installed to facilitate removal of excavated salt (uncontaminated) from drift and support area mining.

WRAC.6.3 Underground Excavation and Facility Setup

After the shafts are completed, drifts will be excavated using commercially available equipment such as continuous miners, roadheaders, scalers, and ventilation paths will be established using air control regulators. Support rooms for use as maintenance areas, control rooms, and packaging areas will be excavated. Air locks will be constructed to isolate the clean areas from the contaminated areas by use of differential pressure. All equipment required for removal, packaging, and related support activities will be installed.

Excavation will be in two phases. The initial excavation will not contact waste but will mine support rooms and haulage drifts that provide ventilation and access to the waste panels. A barrier pillar will be maintained. The size of the barrier piller depends on the anticipated conditions in the waste panels. The barrier pillar will provide protection from blowout or flooding due to pressurized gas or brine. The second phase will remove the waste. Conceptual layout of removal operations is shown in Figure WRAC-7.

Air locks will be used to allow travel between air circuits while maintaining the isolation of contaminated areas from the clean areas. Lined sumps may be used to manage liquids if conditions involving flowing brine are encountered.

The following support areas may be required:

Control Centers. Rooms that contain the remote control support interface between the surface control center and the equipment supporting the underground ventilation, mining, packaging, and transportation operations.

Maintenance Rooms. Shop areas where all maintenance and repairs are performed, including wash bay and parts warehouse for support equipment.

Personnel Support. Lunch room, lockers, washrooms, and facilities.

Container Warehouse. Storage for clean, empty waste containers, and decontamination supplies.

Packaging Area. Waste emplacement into containers, container filling, and container sealing area.

Decontamination Area. Container radiation survey and decontamination area.

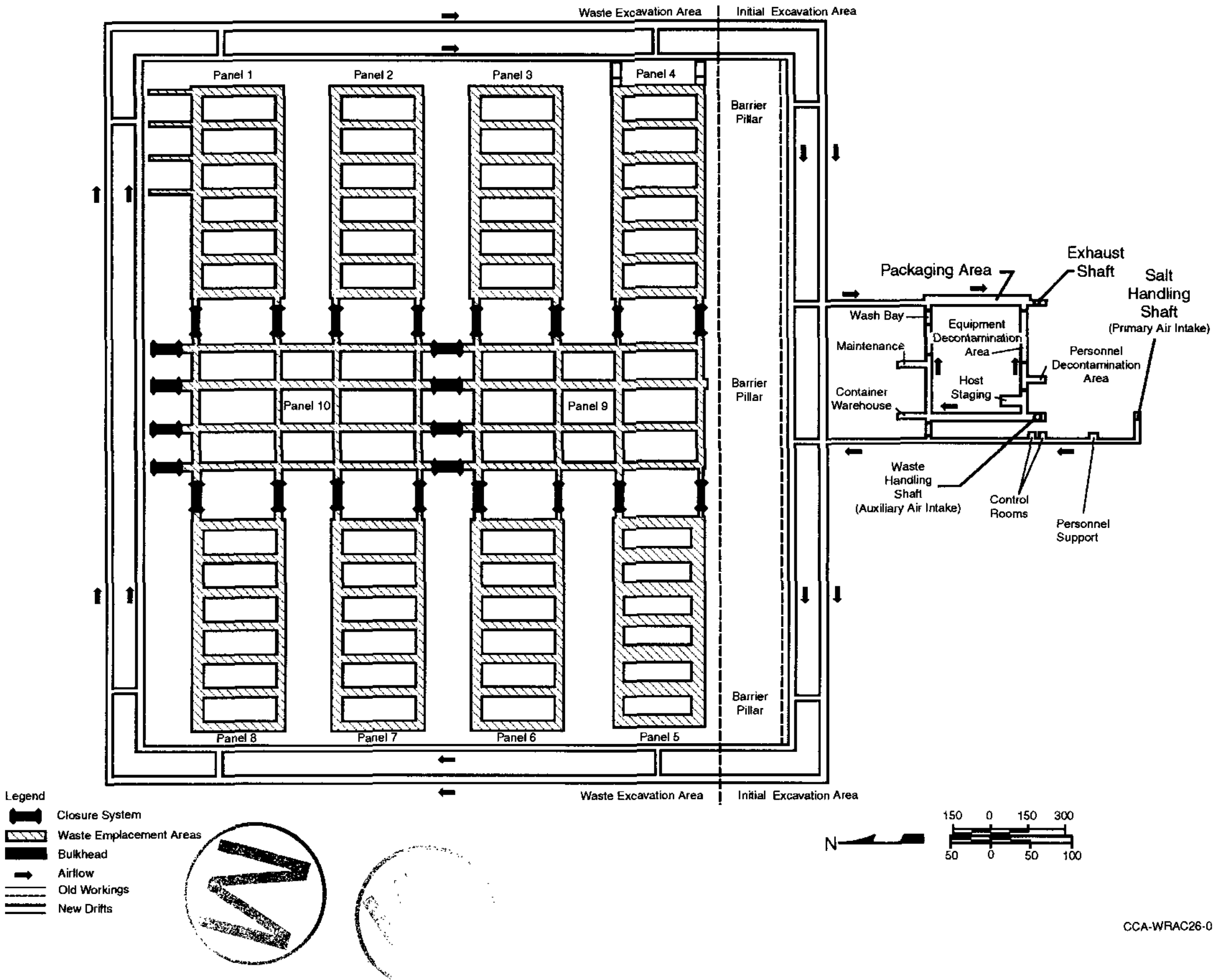

Figure WRAC-7. Repository Removal Operations Layout

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Ore Transfer Station. Virgin salt transfer and removal station at base of shaft.

Container Staging Area. Lower hoist loading area with staging area (clean area) located in clean intake air feeding contamination area; final radiation survey area.

WRAC.6.4 Waste Location and Removal Operations

A single drift should be excavated around the waste panels. This drift will provide ventilation that will be used during removal operations. After the support, ventilation, and access drifts are completed, the first panel can be entered to remove the waste. Panel 9, the panel closest to the exhaust shaft should be excavated first to reduce initial contamination. An entrance and exit will be excavated, dust and moisture control systems installed, and isolation bulkheads erected. The location of the panel closures should be available from the detailed information at record centers and archives. With the exception of mining Panel 9 (the southern most portion of the access drifts) the panel closures can be used as markers for locating panels and drifts. To determine the relative position of the waste, ground penetrating impulse radar technology could be used. Impulse radar technology, specifically a Geophysical Survey Systems, Inc. (GSSI) SIR-7 impulse radar, has been successfully tested in salt mines and has demonstrated the capability of locating metallic targets up to ten meters away (Cook 1982). The access entries could be completed and the entrances to each panel could be located by the panel closure systems and radar. Radar and gamma detectors could be used to help locate the RH-TRU waste. The gamma detectors should be effective during the first few hundred years after disposal prior to extensive decay of the RH radioactivity.

Initially, each waste panel will be evaluated using a small diameter probe hole drilled from the access drifts. The hole will be used to investigate the conditions within the panel. Of particular interest will be the porosity (degree of consolidation), pressure, and moisture content. In addition, gasses will be tested for explosive or flammable constituents.

For conditions requiring that the CH-TRU and RH-TRU waste removal operations be performed in separate operations, the CH-TRU waste will be removed by mining the area where this waste was emplaced. The CH-TRU waste and surrounding rock will be removed and transported to the packaging areas without disturbing the RH-TRU waste. The RH-TRU waste will be removed by excavating the rock salt around the waste and removing it in as intact a condition as possible. This waste may be placed in a waste container at the work face and then transported to the packaging area. The waste container may be the shipping container if sealing and decontamination are possible underground or it may be over-packed at the packaging area prior to decontamination.

The CH-TRU waste can be removed many ways using standard equipment. The waste could be mined out using a large-scale continuous miner. Continuous miners such as the EIMCO Coal Machinery Division's 3612 Marietta Drum Miner (see Figure WRAC-8) have been used very successfully at WIPP and are readily available. However, this method does have the potential to spread excessive amounts of particulate contamination and could be difficult to control particularly with respect to the RH-TRU wastes. A more practical approach would be to use small-scale mining equipment such as road headers, scalers, hydraulic breakers, small loaders, and excavators. A small head continuous miner or a roadheader (telescopic boom miner) similar to a Hawker Siddley DOSCO M.D. 1100 (see Figure WRAC-9) could be used to excavate a large portion of the waste. The other extraction equipment would be used to remove the most difficult waste such as large metallic items.

A practical approach to CH-TRU removal is to excavate an area approximately three feet high directly below the waste and then, using a hydraulic breaker/scaler system similar to the Fletcher Model SV-4D diesel powered scaler capable of being equipped with either an Alpine No Gap cutting head, a percussion scaling hammer, or a scaling claw attachment devices (see Figure WRAC-10) to dislodge the waste above. Similar scaling devices have been successfully utilized at WIPP and other mines in the Delaware Basin.

The CH-TRU waste will be excavated behind bulkheads separating the mining area from normal ventilation. After removing a predetermined amount of excavated materials, loaders will transport the waste materials to the packaging area.

The CH-TRU waste will be transferred to the waste handling and packaging system which packages the waste into containers. Bulk material handling equipment may be used to transfer the waste from the loaders to the waste containers. The container will move into the decontamination area where it is automatically surveyed and decontaminated. The container is then moved into the hoist underground staging area where it is surveyed again and transported to the surface. The container will be warehoused until transported off site.

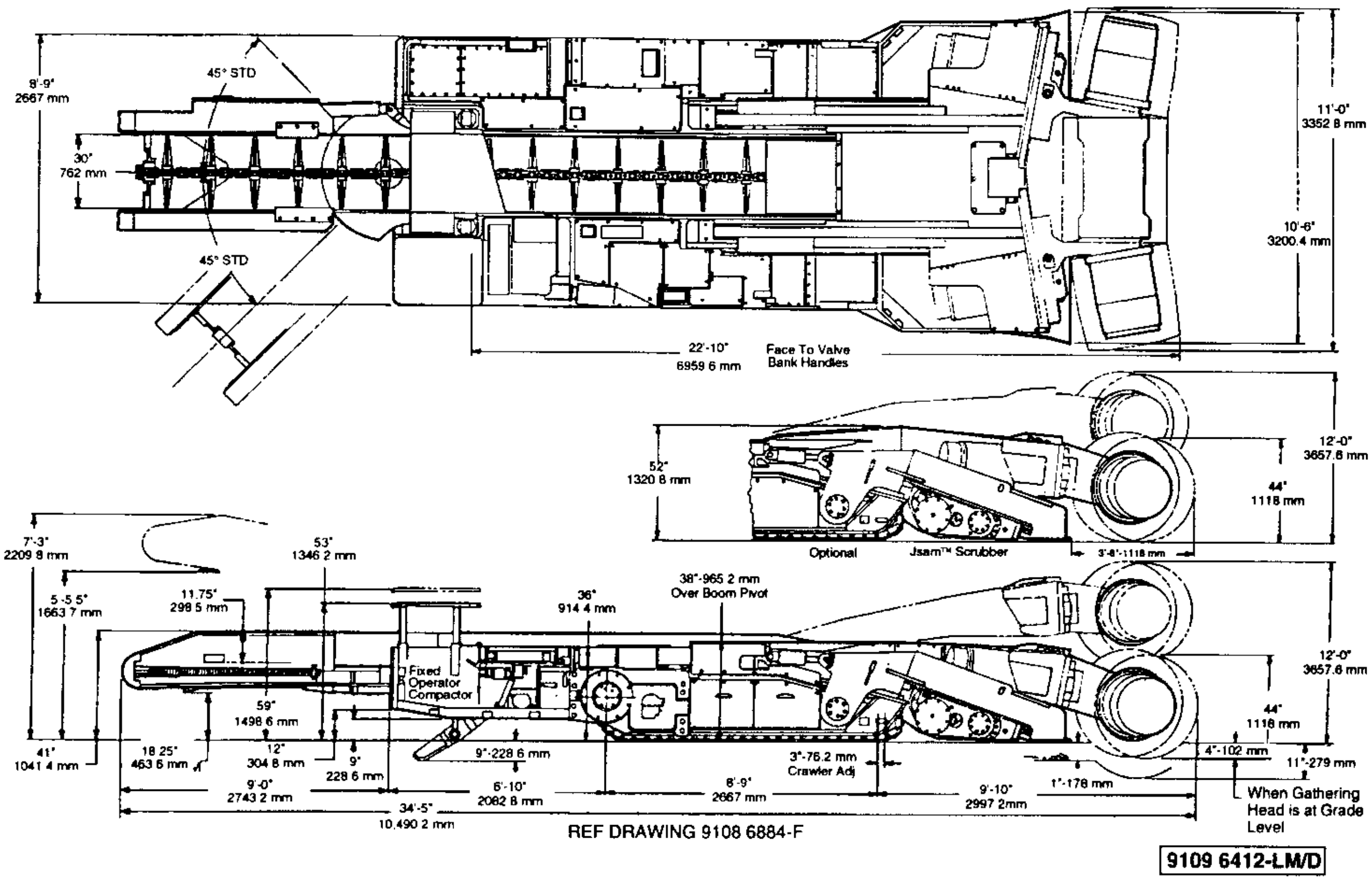
The CH-TRU waste containers will be selected using the regulatory requirements at that time. Currently available containers will be researched to determine their suitability, and if none are found, new containers will be built and certified.

An aboveground decontamination area will be used if any contamination is found during the off-site container loading and transportation operations.

RH-TRU waste will be removed after the CH-TRU waste is excavated past the shield plugs to allow equipment access. The equipment will be set up to remove and excavate the materials around the waste. The waste will be loaded into a container and moved to the packaging area.

There, the container may be decontaminated, if possible, or overpacked prior to shipment aboveground. After completion of any necessary decontamination, the RH-TRU waste will be transported to the surface and then warehoused in a shielded area prior to off-site shipping. Radiation surveying and decontamination procedures will be similar to the CH-TRU operations.

The waste will be removed from the panel and its original access entries. After initial panel waste removal is completed, all other panels will be excavated.



3612 DRUM MINER OPERATING DIMENSIONS

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Figure WRAC-8. EIMCO Coal Machinery Division 3612 Marietta Drum Miner

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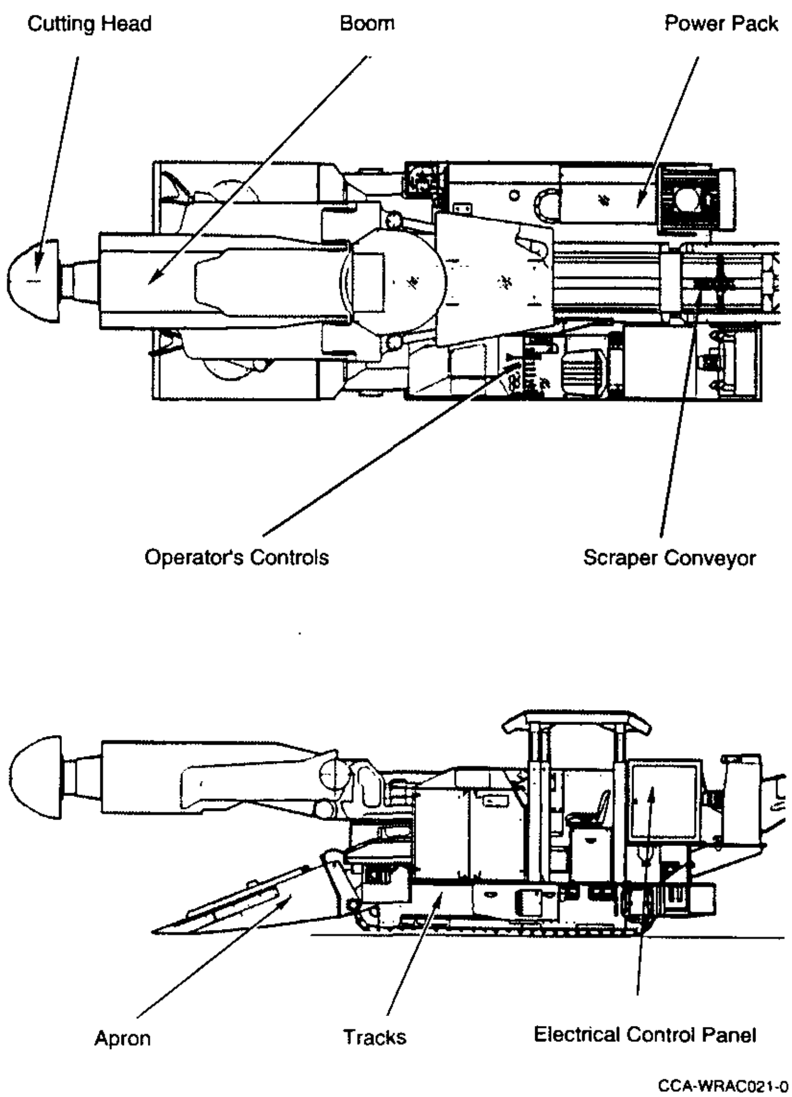

Figure WRAC-9. Hawker Siddley DOSCO MATERIAL DESCRIPTION.1100 Roadheader with Telescopic Boom

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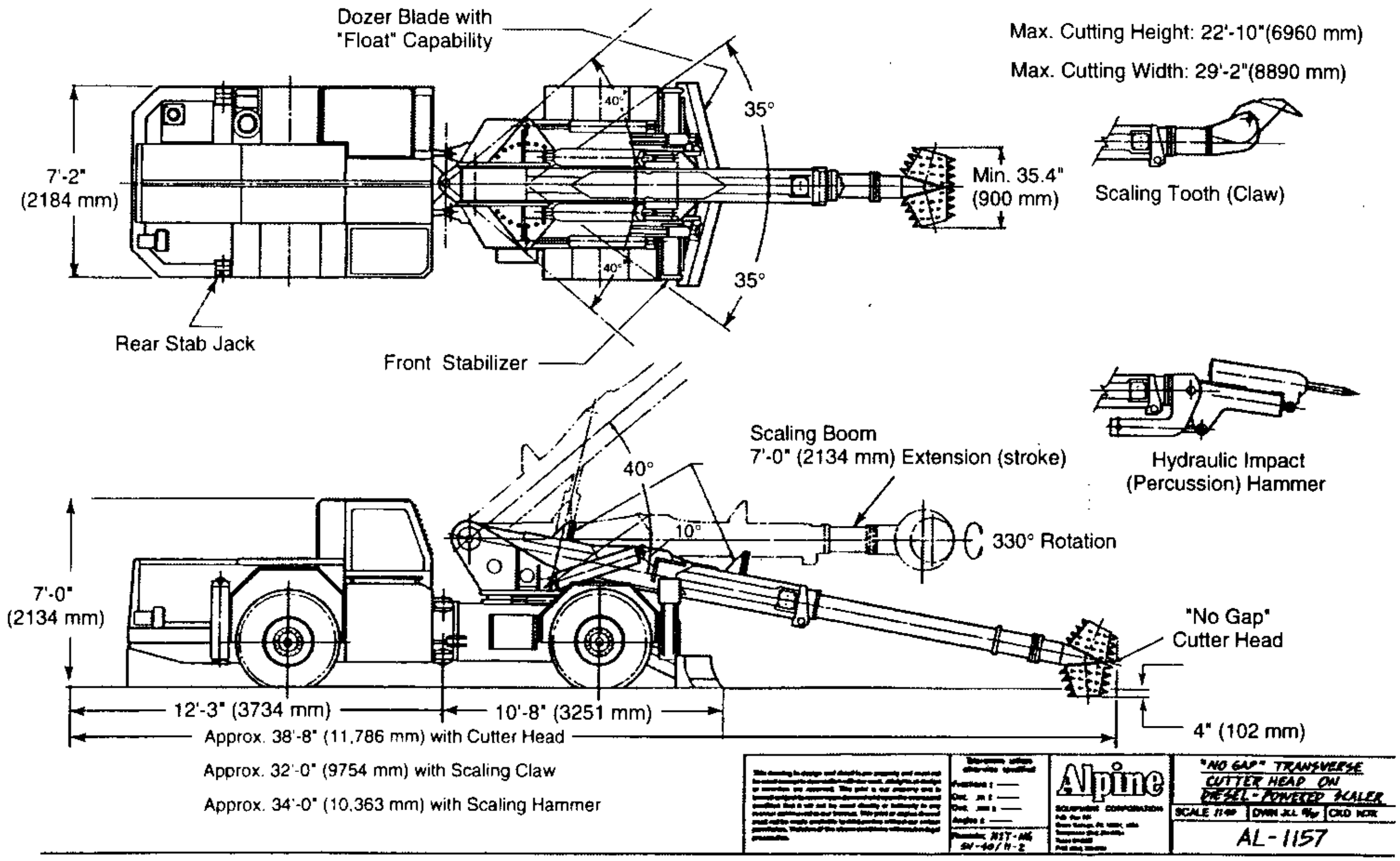

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Figure WRAC-10. Fletcher Model SV-4D Diesel Powered Scaler with Alpine Attachments

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If the removal of waste is not initiated until hundreds of years after disposal and the RH radioactivity has decayed to near the activity levels of the CH waste, the decision may be made to remove the RH waste in conjunction with CH waste removal. Under these conditions, evaluation of the probable condition of the RH containers should be made. The heavier wall thickness of the RH containers may provide an opportunity to remove the RH waste intact provided that corrosion has not yet destroyed the containers' integrity. Under these conditions, RH removal should be conducted in a manner similar to that described above. That is, CH removal within a given panel should proceed until sufficient clearance is obtained to permit installation of equipment to excavate the rock salt around the RH container and then remove the container in as intact a condition as possible. Under conditions which the RH container has lost its integrity, removal of RH waste would be accomplished using the procedures applicable to CH waste removal.

WRAC.6.5 Closure

After the waste is removed from the repository, the facility will be decommissioned in accordance with the regulatory requirements applicable at that time. Closure may include partial backfilling of the mine and support areas. The mine may be used for disposal of both contaminated and uncontaminated muck. The shafts will be sealed (see Appendix SEAL for the details of what a seal may look like) and the surface facilities will be decontaminated and decommissioned (see Appendix D&D for an outline of a decontamination and decommissioning program). All decontamination wastes could be packaged and shipped in the same fashion as the removed waste.

WRAC.7 Currently Available Removal Technologies

As part of the feasibility demonstration, the DOE has identified technologies that are available today that could be used to facilitate removal. These are divided into mining technologies (Section WRAC.7.1) and remote removal technologies (Section WRAC.7.2).

WRAC.7.1 Mining Techniques for Waste Removal

Waste removal can be accomplished in many ways using available technologies. Mining techniques are the most plausible since they must be used initially to provide access to and locate the waste. Methods used to extract salt and potash were briefly evaluated to determine the best removal technique. Since the waste is hazardous and radioactive, the technique used must limit the spread of contamination to the environment and exposure to facility personnel. The condition of the waste at the time of removal will be unknown and is related to the amount of time the waste was exposed to repository conditions.

Removal processes should be performed with as little direct human interaction as possible. Limited contamination is acceptable provided that the exhaust from these areas is controlled and filtered. Roughing filters and HEPA filters can be used to control contamination. Limiting the air throughput in the work areas will minimize the spread of contamination.

Mining techniques that were evaluated include the following:

- continuous mining,
- drill and blast,
- solution mining and mechanical extraction, and
- mechanical excavation techniques.

WRAC.7.1.1 Continuous Mining

Continuous mining was used to excavate most of the WIPP facility. A continuous miner (see Figure WRAC-8) is used to mechanically excavate materials by ripping, milling, or boring the rock from the work face. Rotary drums and heads with cutting bits attached to the surface cut the rock. The miner mechanically removes the loose material and transports it away from the face onto a conveyor where it can be transferred to haulage equipment or transported by belting to other areas. Continuous mining equipment can precisely remove rock and hold tolerances in the order of a few inches. The equipment is available in a wide variety of styles and sizes. Remote controlled continuous miners are commercially available.

The waste contains some metallic items (for example, cadmium, lead, silver) and the containers are steel. Continuous mining heads can be made with bits utilizing various steel alloys. Examples of these alloys include high-strength low alloy (HSLA) ordnance-grade steels such as AISI 4140 chromium molydbenum steel and AISI 8650 nickel chromium molybdenum steels; molybdenum or tungsten-based high speed tool steels such as M2 or T6; and the powder-metallurgy-produced sintered tungsten carbide steel groups such as the six percent cobalt group 2 alloy. All of these alloys are frequently used for various mining, petroleum production drilling, ordnance, and tooling applications such as drilling, mining, and cutting through metals, ores, and hardened rock. The equipment may be further modified by changing the cutting head configuration and sizing to efficiently handle the metallic substances by altering the cutting surface, speed, and bit angles. The need to address cutting through metals, particularly the metal containers, will be dependent upon the time after disposal that removal is initiated (see Chapter 6.0 for performance assessment assumptions regarding metal persistence).

Large-scale continuous mining of the waste is possible but is impractical because of the potential for spreading contaminated material. Excessive amounts of dust are generated during continuous mining. Water is generally used for dust control which may increase the spread of contamination. Water will transport the contamination into the fractures of the surrounding rock.

Small-scale continuous mining of the waste is practical if electric equipment is used and the area is isolated during mining operations. To control contamination, bulkheads can be placed close to the mining face that isolates the mining activities from normal mine ventilation. Ventilation in the mining area can be reduced or eliminated since remote controlled electrical equipment would be used and no diesel equipment or personnel are required. Suspended particles can be effectively removed from the air during mining and loading operations using local HEPA filtered systems with prefiltering capability to reduce the maintenance of HEPA filters.

WRAC.7.1.2 Drill and Blast

This method excavates by drilling holes in a rock face and filling the holes with explosives. The explosion fractures and loosens the rock material. Other equipment is then used to remove the debris and the cycle starts again.

This method could also be used to remove the waste. However, this method generally requires personnel to drill and load and would be difficult to perform remotely. The dust and fumes caused after the explosives are detonated must be ventilated and would cause a contamination problem. Isolating the working areas with bulkheads would be difficult because of the large pressures produced by the blast. Thus, while this method could possibly be used to remove the waste, the associated problems of personnel in the vicinity, ventilation, contamination, and blast side-effects make this method impractical.

WRAC.7.1.3 Solution Mining

Solution mining uses a solvent to extract the material of interest. In salt solution mining, water is injected into the formation and saturated brine is pumped out.

A modified version of this technique could possibly be used to remove the salt from around the waste at the repository level. After the salt is removed, remote controlled mechanical equipment would remove the exposed waste. Hence, both standard mechanical mining methods and solution mining would be required. However, this method would require large amounts of water and would require a system to be designed to recycle the water. Water treatment would also be required to extract salt and any contaminated material. These processes involved add significant complexity to the system and the salt, and probably the water, would still be contaminated and would have to be packaged along with the waste. Additionally, this method would produce a large volume of contaminated material and would spread contaminants into the fractures of the surrounding rock. Therefore, based on the problems of the systems' complexity and of the likely ineffectiveness of those systems, in general, this method is impracticable.

WRAC.7.1.4 Small-Scale Mechanical Excavation Techniques

Smaller-scale mechanical excavation techniques can be used and are the most favorable. One method uses roadheaders, hydraulic breakers, and scalers (see Figures WRAC-9 and WRAC-10) to dislodge material from the face by scaling or cleaving the material. This method is extremely slow and precise. It produces the least amount of dust and can be performed remotely.

Additionally, other forms of mechanical excavation equipment such as Melroe bobcats with various small backhoes, manipulators, and earth moving and cutting attachments (see Figures WRAC-11, WRAC-12, and WRAC-13) exist and would also be used to dislodge, move, cut, and crush the waste. These types of equipment will be required to support any method used.

WRAC.7.1.5 Remote Mining

Two examples of remote mining operations include work in Australia and France. Australia removed 198,334 tons of coal from a McQueen Company mine using a remote controlled flexible conveyor train, a continuous miner, and roof-bolting machines between 1985 and 1987 (McQueen 1988). The French have been actively pursuing remote coal mining since 1972. In 1983, 93 percent of French coal shearers were remotely controlled and monitored. (Boutonnat 1986)

In 1986, the U.S. Bureau of Mines initiated research to develop technology to enable the relocation of workers from hazardous areas (Schnakenberg 1993). Such work includes developing computer assisted operation of continuous miners, roof bolters, and haulage systems (Schnakenberg 1993). Remote mining technology is continuing to progress making the likelihood of its success in any future removal operations highly probable.

WRAC.7.2 Remote Removal

On April 27, 1992, a retrieval demonstration took place that successfully retrieved SWBs from a WIPP storage room. This demonstration simulated a cave-in or roof fall condition with salt and metal roof support materials piled on top of the SWBs. All retrieval operations were performed using remote controlled equipment.

The equipment used for this demonstration consisted of two remote controlled Melroe bobcats (see Figures WRAC-11 thru WRAC-16), a remote controlled freestanding portable television camera, a WILD TM 3000 automatic laser survey station, a portable beta-gamma radiation detector, and an ANDROS Mark VA hazardous duty robot (see Figure WRAC-17). One remote-controlled bobcat used a backhoe attachment and the other used either a manipulator, front loader bucket, hydraulic breaker, or grapple bucket attachment. The attachments were changed out when required. The equipment used both radio and tethered cable remote control methods.

The demonstration used the robot to survey the areas using television cameras and laser ranging equipment. The condition and location of the SWBs were determined using the robot's data. The robot also set up equipment and surveyed the areas for radioactive contamination.

In order to remove the SWBs, the salt and metal materials were removed and boxed in containers using the remote controlled equipment. The SWBs were successfully removed from the room.

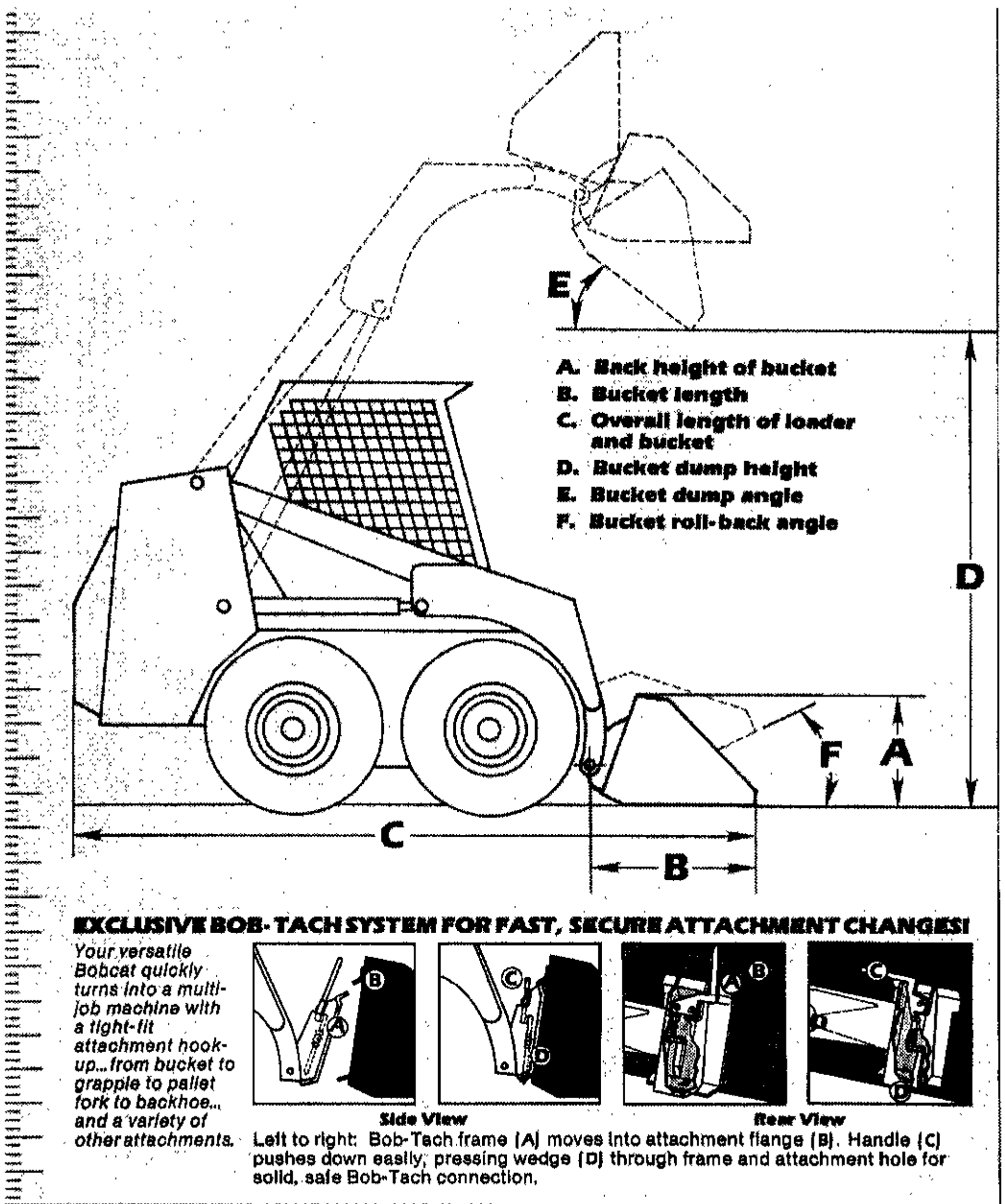

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Figure WRAC-11. Melroe Schematic Drawing

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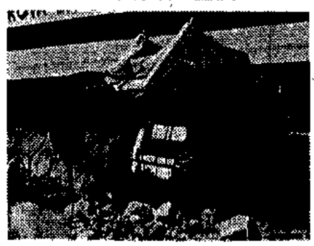
FOR 700, 800 AND 900 SERIES AND ARTICULATED 1600, 2400 MTC LOADERS

INDUSTRIAL FORK GRAPPLE

Handle scrap and assorted metal. Bobcat fork grapples join the other Bob-Tach attachments that allow change ability from the operators cab. The Fork grapple is perfect for handling sharp, irregular-shaped metal, other assorted scrap and heavy duty agricultural applications.

FOR BOBCAT 443, 500, 600, 700, 800, 900 SERIES, AND ARTICULATED 2400 MTC LOADERS

HYDRAULIC BREAKER



Break up concrete quick and easy.*

- Up To 750 Ft.-Lb. impact energy class.
- Backhoe or Loader Mounting.
- *2-position Loader Mounting Frame for Vertical and Horizontal Breaking.*
- Quick-Change Tool System – Variety of Tools Available.
- Low Recoil Operating Cycle.

FOR BOBCAT 600, 700, 800 AND ARTICULATED 1600, 2400 MTC LOADERS

LANDSCAPE RAKE

Grade, level and scarify in close quarters. Break up lumpy soil, pick up rocks as small as 3/4", grade, level and scarify in close quarters *with the Bobcat Landscape Rake. Use it for* ground preparation, for seeding, sodding and lawn leveling. Pick up rocks or hard-packed clumps of soil and dump them where you need them with the Bobcat Landscape Rake.

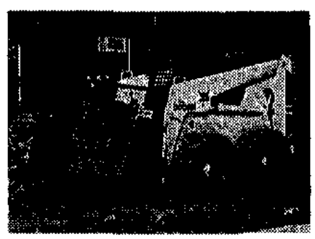
AN ALLIED ATTACHMENT FOR BOBCAT 740s, 843, 900 AND ARTICULATED 1600, 2400 MTC LOADERS

LONGWOOD GRAPPLE

Turn your Bobcat into a high performance log handler. The Multitek Longwood Grapples* are made of high quality steel providing strength and durability for rough working conditions.

FOR BOBCAT 500, 600, 700, 800 AND 900 SERIES AND ARTICULATED 1600, 2400 MTC LOADERS

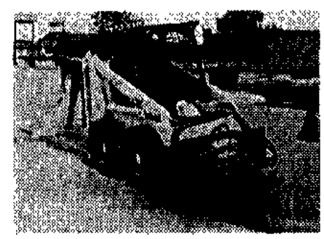
PALLET FORK



Move bulky or bagged materials in one load. Hook on a Bobcat pallet fork and move your bagged or bulk material fast. Ideal for all kinds of farm chores and fertilizer handling. In industrial plants and landscaping, handle baled or pallet materials

FOR BOBCAT 843 SERIES LOADERS

PLANER



Cut and remove deteriorated asphalt. The Bobcat 843 becomes an effective, cost-efficient planing machine* with the Melroe Planer attachment. Quickly removes deteriorated asphalt surfaces. An ideal tool for busy municipal and construction contractors.

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Figure WRAC-12. Melroe Bobcat Optional Attachments

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Figure WRAC-13. Melroe Bobcat Optional Attachments

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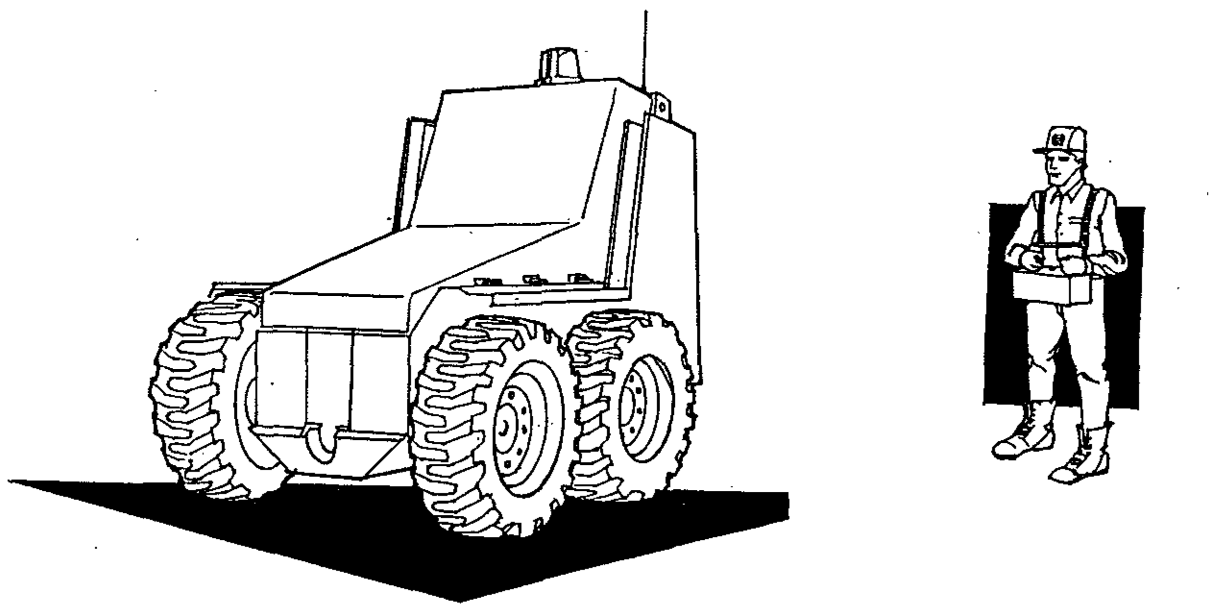

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Figure WRAC-14. Modified Remote-Controlled Melroe Bobcat Without Attachments

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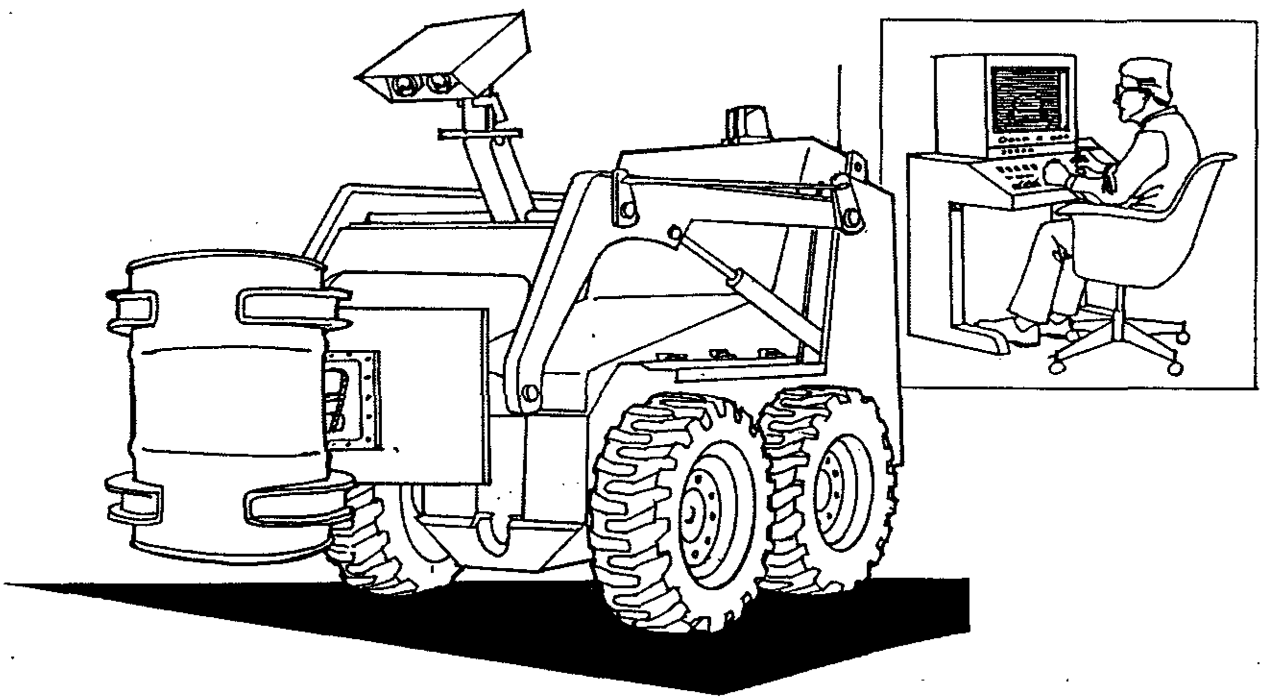

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Figure WRAC-15. Modified Remote-Controlled Melroe Bobcat With Manipulator Attachments

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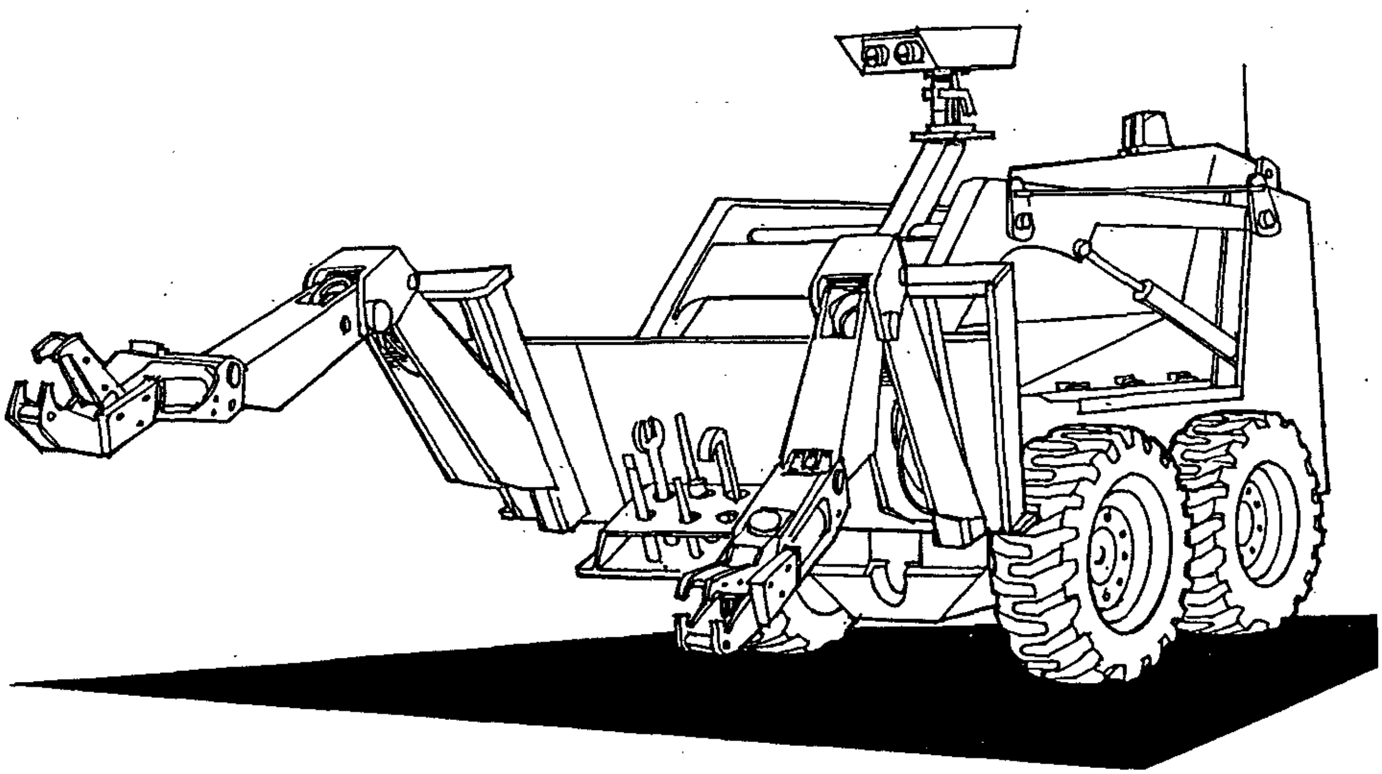

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Figure WRAC-16. Modified Remote-Controlled Melroe Bobcat With Manipulator Attachments

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Figure WRAC-17. REMOTEC ANDROS Robotic Probe

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Although the retrieval demonstration was performed on a small scale, it proved that remote controlled equipment could be used to remove salt and metal materials from around a waste container, package the excess material, and remove the waste container. The removal of waste from a consolidated salt condition will involve a more complex set of circumstances. However, current technological capabilities permit remote operation of current equipment and will permit these complexities to be solved operationally. Thus, no new technology will be required.

Current technology exists and is in operation in mines throughout the world to excavate materials using remote controlled machinery. Remote coal mining has been performed for many years by countries including Australia, France, Austria, Canada, Russia, and the United States. Remote controlled continuous miners, rock bolters, drills, haulage, road headers, loaders, and locomotives are examples of the equipment used at these mines (Naunkovic 1986).

WRAC.8 Conclusion

The requirement for waste removal after closure originates in 40 CFR § 191.14(f). Specifically, 40 CFR § 191.14(f) states that WIPP disposal systems will be selected so that removal of the waste is not precluded for a reasonable period of time after disposal (EPA 1993). Removal of the waste after the repository is sealed is possible. Because access to the repository was accomplished using standard mining practices, access to the waste after closure can be accomplished using the same mining technologies supplemented by a more extensive use of remote controlled and robotic equipment. The degree of robotic and remote controlled technology required to successfully remove the waste is not only available and but also has been used in mining and industrial packaging activities around the world. The accessibility for waste removal has no operational time limit assuming use of today's technology. 40 CFR § 194.46 states that the analysis of the technological feasibility of removing the waste use "...technology levels at the time a compliance application is prepared." Locating and removing the waste is feasible using currently available equipment modified to operate remotely. Packaging the removed waste and decontaminating the containers can be safely accomplished by using established techniques. The concept of sealing and decommissioning the facility will have been demonstrated prior to waste removal.

As stated in the preamble to 40 CFR Part 191, with respect to the waste removal requirement:

> Any current concept for mined geologic repository meets this requirement without any additional procedures or design features. For example, there is no intent to require that the repository shafts be kept open to allow future recovery. To meet this assurance requirement, it only need be technically feasible (assuming current technology levels) to be able to mine the sealed repository and recover the waste - albeit at substantial cost and occupational risk.

The WIPP is a mined geologic repository and, as such, meets the removal requirement without any additional design requirements since current technology can be used to remove the waste if the need arises. Examples of the necessary mining equipment are in existence today, are readily available, and have been effectively used for mining applications. Thus, it is logical to conclude that since the necessary equipment not only exists in off the shelf forms but also has been effectively used in a variety of mining applications, then waste removal utilizing this equipment is feasible. Partial proof of this concept has already been demonstrated by retrieving waste containers from under salt and metal roof support materials using remote controlled equipment.

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